Appendix B Electricity Price Calculation

The electricity price in ReEDS is calculated after the optimization, based on the installed capacity and dispatch in that period. The output electricity price, reported by balancing area, is a weighted average of the electricity prices for each time-slice. Electricity prices within time slices are calculated differently depending on whether the region is a net-importer or -exporter.

$$ElecPrice_n = \frac{\sum_m \begin{cases} Pelec_{n,m} \cdot gen_{n,m} & \text{if } gen_{n,m} \geq load_{n,m}, \\ Pelec2_{n,m} \cdot load_{n,m} & \text{if } gen_{n,m} < load_{n,m}. \end{cases}}{\sum_m \begin{cases} gen_{n,m} & \text{if } gen_{n,m} \geq load_{n,m}, \\ load_{n,m} & \text{if } gen_{n,m} < load_{n,m}. \end{cases}}$$

$gen_{n,m}$ is generation in balancing area n in time-slice m. (MWh)

$load_{n,m}$ is the load in balancing area n in time-slice m. (MWh)

If the region is a net-exporter in timeslice m, $Pelec_{n,m}$, the unadorned cost of generation, is used as the price of electricity:

$$Pelec_{n,m} = pgen_{n,m} + NGTC_n$$

If the region is a net-importer in the timeslice, however, $Pelec2_{n,m}$—which includes the price of imports, $pimports_{n,m}$—is used as the price of electricity instead:

$$Pelec2_{n,m} = (gen_{n,m} \cdot pgen_{n,m} + (load_{n,m} - gen_{n,m}) \cdot pimports_{n,m}) / load_{n,m} + NGTC_n$$

$NGTC_n$ (Non-Generation Transaction Cost) is a scalar set after the first time period to normalize the calculated 2006 electricity prices with historical data. It represents components of the electricity price not explicitly represented in ReEDS (e.g. distribution costs, administration costs, etc.). ($/MWh)

The price of generation, $pgen_{n,m}$ is calculated from various components: return on ratebase, O&M costs for renewable and conventional technologies, and fuel costs. Calculations of the components of $pgen_{n,m}$ are shown in a separate section below.

$$pgen_{n,m} = \left(Ratebase_n \cdot disc + WindOM_n + CSPOM_n + \sum_q CfixOMtot_{n,q} + \sum_{st} FSTORtot_{n,st} \right) / ngen_n + (CfuelvOM_{n,m} + STORfuelOM_{n,m}) / gen_{n,m}$$

$ngen_n = \sum_m gen_{n,m}$, total generation in area n, summed over time-slices. (MWh)

$disc$ is the real discount rate, 8.5% in the Base Case.

$Ratebase_n$: book value of all installed capacity in area n. ($)

$WindOM_n$: O&M costs for all wind feeding balancing area n. ($)

$CSPOM_n$: O&M costs for all CSP feeding balancing area n. ($)

$CfixOMtot_{n,q}$: fixed O&M costs for conventional technology q in area n. ($)

$FSTORtot_{n,st}$: fixed O&M costs for storage technology st in area n. ($)

$CfuelvOM_{n,m}$: variable O&M and fuel costs for conv. in area n in time-slice m. ($)

$STORfuelOM_{n,m}$: variable O&M and fuel costs for storage in area n, time-slice m. ($)

The price of imports in region n, $pimports_{n,m}$, is calculated from the wheeling price, $pwheeled_{n,m}$, the cost of generation in source region p in time-slice m.

$$pimports_{n,m} = \frac{\sum_p CONVT_{p,n,m} \cdot H_m \cdot (pwheeled_{p,m} + translcoe_{p,n})}{\sum_p CONVT_{p,n,m} \cdot H_m}$$

$CONVT_{p,n,m}$ is transmission of conventionals from balancing area p to n in time-slice m. (MW)

$pwheeled_{p,m}$ is the cost of electricity either generated in or transmitted through region p in time-slice m. ($/MWh)

$translcoe_{p,n}$ is a cost adder for transmission. ($/MWh)

The Components of pgen

Ratebase$_{y,n}$ is the book value of all installed capacity in balancing area n in time period y.

$$Ratebase_{y_o,n} = Ratebase_{y_o-1,n} + Investment_{y_o,n} - .066 \cdot Ratebase_{2006,n} - \sum_{y_o-lt/2<y<y_o} .066 \cdot Investment_{y,n}$$

(n.b. We only subtract off the 2006 Ratebase piece through 2036.)

y_o is the time period (year).

lt is the investment lifetime, 30 years in the Base Case.

$Investment_{y,n}$ is the total capital investment (for wind, CSP, conventionals, and storage) in area n in period y.

WindOM$_n$: The total O&M costs for wind are simply capacity multiplied by the sum of the fixed and variable O&M costs for class c wind. An average O&M cost for existing wind in class c by region j is updated after each time period to account for new builds ($CWOMold_{c,j}$, $CWOMTold_{c,j}$). Many of the quantities in the following formulae are outputs from the optimization, so definitions and explanations can be found among the variables in Section A.2 or in the glossary, Section A.5.

$$WindOM_n = \sum_{c,i,j,l}^{j \in n} (WN_{c,i,j,l} + WTN_{c,i,j,l} + Wtur\_inregion_{c,j,l}) \cdot CWOM_{c,l} + \sum_{c,i,j,l}^{j \in n} (WO_{c,i,j,l} \cdot CWOMold_{c,j,l} + WTO_{c,i,j,l} \cdot CWOMTold_{c,j,l})$$

CspOM$_n$: O&M costs for CSP are calculated the same way as for wind:

$$CspOM_n = \sum_{cCSP,i,j}^{j \in n} (CspN_{cCSP,i,j} + CspTN_{cCSP,i,j} + CSPtur\_inregion_{cCSP,j}) \cdot CspOM_{cCSP} + \sum_{cCSP,i,j}^{j \in n} (CspO_{cCSP,i,j} \cdot CspOMold_{cCSP,j} + CspTO_{cCSP,i,j} \cdot CspOMTold_{cCSP,j})$$

CfixOMtot$_{n,q}$: The fixed O&M costs for conventionals are calculated by adding the costs for new capacity to the tracked expenses from existing capacity.

$$CfixOMtot_{n,q} = \sum_{q} CfixOM_{n,q} \cdot (CONV_{n,q} - CONVold_{n,q} - CONVret_{n,q}) + CfixOMold_{q} \cdot CONVold_{n,q}$$

FSTORtot$_{n,st}$: Fixed O&M costs for storage are also calculated by adding costs for new installations to the previous time period's costs.

$$FSTORtot_{n,st} = \sum_{st} FSTORold_{n,st} \cdot old\_STOR_{n,st} + FSTOR_{st} \cdot STOR_{n,st}$$

CfuelvOM$_{n,m}$, **STORfuelOM$_{n,m}$**: The variable O&M and fuel cost calculations use fuel prices for the period, not life cycle fuel costs, and include applicable carbon taxes.

$$CfuelvOM_{n,m} = \sum_{q} (CONVgen_{n,m,q} + CONVP_{n,m,q} \cdot Pcostfrac) \cdot H_{m} \cdot (CConvVOMold_{n,q} + Heatrateold_{n,q} \cdot (Fprice_{n,q} + CarbTax \cdot CONVpol_{q,CO2}))$$

$$STORfuelOM_{n,m} = \sum_{st} (STORout_{n,m,st} \cdot H_{m} \cdot (VSTORold_{n,st} + StHeatrateold_{n,st} \cdot (Fprice_{n,st} + CarbTax \cdot STORpol_{st,CO2}))$$